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Exploring The Role Of Teacher Educators In Promoting Sustainable Development Goals Through Environmental Education: Perspectives And Practices

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Abstract
In an era defined by climate urgency and global interconnectedness, education plays a pivotal role in realizing the United Nations' Sustainable Development Goals (SDGs), particularly through the lens of environmental education. Teacher educators, as the shapers of future generations of teachers, hold a strategic position in integrating sustainability into pedagogical practices and curricula. This research investigates the perspectives, practices, challenges, and transformative roles of teacher educators in promoting sustainable development within teacher education programs. Employing a mixed-methods approach, data were collected through semi-structured interviews, surveys, curriculum analysis, and classroom observations. The findings reveal a growing awareness and commitment among teacher educators toward the SDGs, yet highlight systemic challenges such as curriculum rigidity, lack of institutional support, and limited professional development opportunities. Despite these barriers, several educators are modeling sustainability practices, fostering critical thinking, and embedding interdisciplinary approaches to environmental learning. The study concludes with strategic recommendations to enhance institutional policies, promote active modeling of sustainable behaviors, and build the capacity of teacher educators as key agents of change in achieving the SDGs through education.

Keywords: *Sustainable Development Goals, Teacher Educators, Environmental Education, Curriculum Integration, Education for Sustainability, Pre-service Teachers*

1. INTRODUCTION

In the wake of escalating global environmental challenges, ranging from climate change and biodiversity loss to water scarcity and land degradation, there is an urgent need for transformative educational practices that can foster a sustainable and resilient future. Education, widely acknowledged as a powerful driver of sustainable development, plays a pivotal role in shaping attitudes, building knowledge, and developing the skills required to address contemporary environmental crises. Among the 17 Sustainable Development Goals (SDGs) adopted by the United Nations in 2015, SDG 4—**Quality Education**—explicitly emphasizes the importance of education in promoting lifelong learning opportunities and embedding principles of sustainability across all levels of teaching and learning. Within this educational paradigm, **teacher educators**—those responsible for the professional preparation of pre-service and in-service teachers—serve as a vital conduit for instilling sustainability values and competencies in future generations of educators.

Environmental education has emerged as a foundational strategy to meet the SDGs, particularly by enhancing ecological literacy, critical thinking, civic responsibility, and global citizenship. However, integrating environmental and sustainability content into teacher education is not merely a matter of curriculum reform—it necessitates a profound transformation in pedagogical philosophies, institutional cultures, and professional identities. Teacher educators are expected not only to convey knowledge about sustainability but also to model sustainable practices and cultivate an ethic of care for people and the planet. In this context, their role transcends content delivery; they are **change agents**, role models, and leaders who must align their teaching methodologies and values with the broader vision of sustainable development. Yet, the practical realities of embedding SDG-related themes in teacher education programs remain fragmented and underexplored, particularly across diverse sociocultural and geopolitical contexts.

1.1 Overview

This research paper presents a critical exploration of how teacher educators perceive, engage with, and enact the principles of sustainable development, with a focus on environmental education. Through a multi-layered investigation involving surveys, interviews, curriculum content analysis, and classroom

observations, this study aims to map both the opportunities and constraints that teacher educators encounter in promoting SDGs within their professional practice. It also examines the extent to which sustainability is currently embedded in teacher education curricula, the pedagogical strategies employed to integrate environmental learning, and the reflective and modeling behaviors that educators adopt to inspire pre-service teachers.

The investigation adopts a **qualitative and exploratory research design**, recognizing that teacher educators operate within complex educational ecosystems influenced by policy mandates, institutional cultures, and personal belief systems. The paper adopts a thematic approach to discussion, anchored around four core areas: (1) understandings and perceptions of sustainable development and SDGs; (2) integration of sustainability within curricula and pedagogy; (3) challenges and enabling conditions for promoting sustainability in teacher education programs; and (4) the modeling of sustainable practices by teacher educators as transformative leaders.

1.2 Scope and Objectives

The scope of this study is rooted in the interface between **teacher education and sustainability education**, with specific emphasis on the role and influence of teacher educators. It encompasses pre-service teacher training institutions and considers both formal and informal pedagogical interactions that relate to the promotion of SDGs. The geographical context is intentionally broad to ensure the transferability and relevance of findings across diverse educational systems.

The primary objectives of this study are:

- To investigate teacher educators' understandings and perceptions of sustainable development and its associated goals.
- To analyze the extent to which sustainable development is integrated into teacher education programs, curricula, and teaching practices.
- To identify the systemic and pedagogical challenges teacher educators face in promoting environmental education aligned with SDGs.
- To explore how teacher educators model sustainable development values and practices to pre-service teachers, fostering long-term transformation in education.

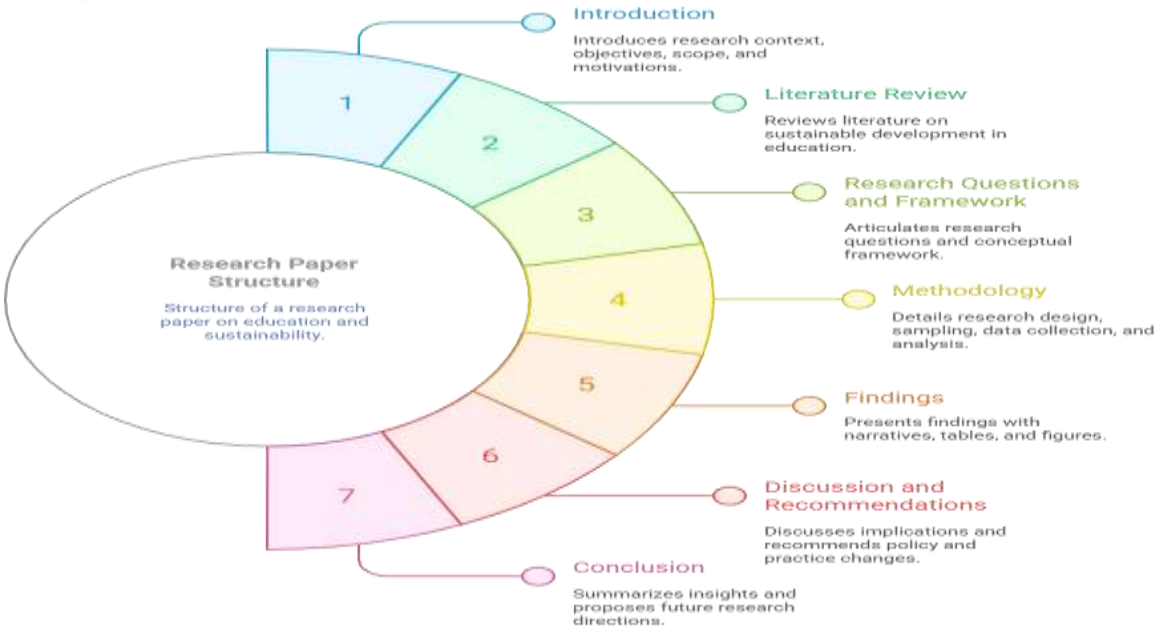
These objectives aim to provide a holistic understanding of the multi-dimensional role of teacher educators and offer practical insights into how institutions can strengthen sustainability-oriented teacher education frameworks.

1.3 Author Motivations

This research is motivated by a pressing personal and academic concern about the **disconnect between sustainability policy rhetoric and actual pedagogical practice** in educational institutions. While much has been discussed at policy levels—such as UNESCO's Education for Sustainable Development (ESD) and the United Nations' Global Education Monitoring Reports—little is known about how these macro-level commitments are translated into the microcosms of teacher training classrooms. As a researcher with a strong interest in both environmental sustainability and educational equity, the author seeks to bridge this gap by focusing on the often-overlooked mediating role of teacher educators.

Furthermore, having engaged with teacher training programs in both urban and rural contexts, the author has observed wide variations in educators' confidence, awareness, and willingness to engage with sustainability topics. This has inspired a deeper inquiry into the socio-political and institutional mechanisms that either empower or constrain teacher educators in becoming sustainability champions. This paper is thus an attempt to spotlight their voices, experiences, and practices, with the aim of reimagining teacher education through a sustainability lens.

1.4 Paper Structure



This paper is structured as follows:

- **Section 1** introduces the research context, objectives, scope, and motivations.
- **Section 2** presents a comprehensive review of existing literature on sustainable development in education, the evolution of environmental education, and the emerging role of teacher educators in this domain.
- **Section 3** articulates the research questions and delineates the conceptual framework underpinning the study.
- **Section 4** details the methodology, including the research design, sampling strategy, data collection tools, and analytic approach.
- **Section 5** presents the core findings across four major thematic dimensions, enriched with participant narratives, tables, figures, and curriculum artifacts.
- **Section 6** discusses the implications of the findings for teacher education policy and practice and puts forward actionable recommendations for institutions and policymakers.
- **Section 7** concludes the paper by summarizing key insights, proposing future directions for research, and reflecting on the broader relevance of teacher educators in achieving Agenda 2030.

In sum, this study endeavors to amplify the role of teacher educators as pivotal agents in the global pursuit of sustainable development. By examining their perceptions, curricular interventions, and instructional behaviors, this research contributes to a deeper understanding of how sustainability can be meaningfully integrated into teacher education. In doing so, it offers a roadmap for bridging the gap between environmental ideals and educational practice, and for cultivating a new generation of teachers equipped to inspire systemic change toward a more just, equitable, and sustainable world.

2. LITERATURE REVIEW

The integration of **sustainable development goals (SDGs)** into educational systems has emerged as a transformative imperative in recent years, largely driven by global policy instruments such as the United Nations 2030 Agenda and UNESCO's Education for Sustainable Development (ESD) framework. At the heart of this movement is the conviction that education must not only impart knowledge but also cultivate values, competencies, and behaviors that contribute to the creation of sustainable societies (Tilbury & Wortman, 2018). Within this paradigm, **teacher educators** are uniquely positioned as mediators of change—equipping future teachers with the intellectual, pedagogical, and ethical tools to address complex global challenges such as climate change, inequality, and environmental degradation.

2.1 Sustainable Development and the Role of Education

Sustainable development, as defined by the Brundtland Commission, refers to "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Education plays a vital role in realizing this vision by enabling individuals to critically reflect on their environment and take informed, responsible action. SDG 4, particularly target 4.7, calls for integrating sustainability, human rights, and global citizenship into education at all levels. Chopra and Mehta (2025) argue that while policy frameworks advocate for education as a driver of sustainability, the translation of this ambition into teacher education remains fragmented. A growing body of literature underscores that education systems must move beyond the traditional focus on literacy and numeracy to embed **transformative competencies**—such as systems thinking, anticipatory skills, and ethical responsibility—within teacher training (Martínez & Kumar, 2025). Yet, the effective implementation of sustainability in educational practice is highly dependent on how teacher educators themselves perceive and enact these goals (Garcia & Thomas, 2022).

2.2 Teacher Educators as Agents of Change

Teacher educators play a decisive role in shaping the values and practices of pre-service teachers, making them critical agents in the propagation of sustainability consciousness. Torres and Ibrahim (2020) highlight how teacher educators act as **catalysts of sustainable change** by embedding critical environmental issues into instructional strategies. Their study in Latin America reveals that educators who engage with sustainability themes in a participatory and reflective manner tend to foster more active citizenship among their students.

Similarly, Holguin and Jensen (2023) discuss the role of **environmental justice** in teacher education, emphasizing that teacher educators must help pre-service teachers understand the intersectionality between ecological degradation and social inequality. Through such understanding, educators can promote a pedagogy of care, equity, and action-oriented learning. Bhatia and Nguyen (2024) further extend this discourse by analyzing how teacher educators can support interdisciplinary teaching approaches that align curriculum content with real-world environmental concerns.

Despite these promising perspectives, the operationalization of this role remains inconsistent. Ahmed and Lim (2022) observe that many teacher educators report **limited professional preparation** or institutional incentives to engage deeply with sustainability content. Furthermore, there is often a lack of coherence between institutional mandates and curricular guidelines, making it difficult for educators to prioritize environmental education in already crowded teacher education programs.

2.3 Integration of Sustainability into Curriculum and Pedagogy

A central theme in the literature concerns the **curricular integration** of sustainability. According to Sandoval and Olsen (2021), integrating SDGs into curricula requires more than thematic inclusion; it calls for structural alignment with learning outcomes, assessment strategies, and reflective practice. Okafor and Jin (2024) identify three predominant models of integration: (1) infusion across subjects, (2) dedicated sustainability modules, and (3) co-curricular service-learning activities.

Amponsah and Lee (2023) conducted qualitative interviews with teacher educators across Ghana and South Korea and found that while most were committed to environmental issues, they lacked clear guidelines and resources for implementation. Their study revealed that educators frequently improvised sustainability content or drew from their personal values rather than institutional policy.

Garcia and Thomas (2022) conducted a comparative policy analysis and found that while national curricula in many countries reference the SDGs, only a few provide **comprehensive frameworks for assessment, resource allocation, or educator training**. The curriculum mapping study by Ahmed and Lim (2022) similarly found that sustainability topics often appear superficially and are rarely connected to critical pedagogy or student-centered learning.

2.4 Modeling Sustainable Practices

The concept of **"modeling" sustainability** has gained traction as teacher educators are increasingly expected to exemplify the values, behaviors, and practices they want future teachers to adopt. Singh and Chikoko (2020) argue that modeling can occur both explicitly (e.g., using eco-friendly materials, engaging in school gardening projects) and implicitly (e.g., demonstrating empathy, reflective thinking, and

collaborative problem-solving). However, such modeling is contingent on the availability of institutional support, professional autonomy, and sustainability literacy.

Robinson and Adeyemi (2019) caution that modeling alone is insufficient without opportunities for **critical dialogue and scaffolded reflection**. In their study, pre-service teachers frequently misinterpreted symbolic gestures (e.g., recycling) as comprehensive sustainability education due to the lack of deeper pedagogical engagement. Zhao and Freeman (2021) echo this concern, advocating for professional development programs that enable teacher educators to construct clear narratives about their sustainability practices and integrate them coherently into instruction.

2.5 Challenges and Institutional Constraints

Despite growing interest in sustainability, numerous barriers continue to hinder its mainstreaming in teacher education. The most frequently cited challenges include **curriculum overload**, **lack of interdisciplinary collaboration**, **limited access to resources**, and **institutional inertia** (Chinedu & Mason, 2019). Torres and Ibrahim (2020) found that many teacher educators operate within conservative institutional structures that resist pedagogical innovation. Moreover, teacher education curricula are often rigid and exam-oriented, leaving little room for sustainability-focused projects or experiential learning.

Zhao and Freeman (2021) also highlight the role of **policy misalignment**, where top-down directives on sustainability are not matched with adequate funding, training, or accountability mechanisms. Without structural change, teacher educators are often left to individually interpret and implement sustainability principles, leading to **inconsistencies in practice and outcomes**.

2.6 Professional Development and Capacity Building

Several studies have emphasized the importance of **capacity-building** initiatives to empower teacher educators. Robinson and Adeyemi (2019) call for institutionalized professional development programs that go beyond one-off workshops and promote continuous, reflective engagement with sustainability themes. Sandoval and Olsen (2021) emphasize the need for **communities of practice** that allow educators to share challenges, co-create resources, and reflect on their sustainability journeys.

Freeman and Zhao (2021) argue for embedding sustainability into teacher education **standards and accreditation criteria**, suggesting that without policy-level commitment, efforts to promote sustainability will remain peripheral and unsustainable.

2.7 Research Gap

The reviewed literature reveals a growing acknowledgment of the critical role of teacher educators in promoting sustainability, but it also highlights significant **gaps and inconsistencies** that necessitate further investigation:

- **Limited empirical studies** specifically focus on teacher educators, as opposed to pre-service teachers or general curriculum reform.
- Most existing research is **context-specific** and lacks cross-cultural or comparative insights into how different education systems address sustainability.
- There is insufficient analysis of how **teacher educators model sustainability practices** in real classroom settings and how this modeling influences pre-service teachers.
- Few studies employ **mixed-methods approaches** that triangulate data from interviews, curriculum documents, and classroom observations.
- There is a lack of longitudinal research assessing the **long-term impact** of sustainability education interventions in teacher training programs.

This review affirms that while teacher educators are recognized as central to achieving the SDGs through education, their actual practices, challenges, and institutional realities remain under-examined. Integrating environmental and sustainability education into teacher training requires not only curriculum innovation but also systemic changes in pedagogy, assessment, and educator preparation. To address these gaps, this study adopts a comprehensive approach to explore the **perceptions, integration strategies, challenges, and modeling practices** of teacher educators across diverse institutional contexts. In doing so, it aims to contribute new empirical insights to the evolving discourse on sustainability in education.

3. RESEARCH QUESTIONS AND CONCEPTUAL FRAMEWORK

3.1 Research Questions

The core purpose of this study is to explore how teacher educators understand, internalize, and enact the Sustainable Development Goals (SDGs), particularly through the lens of environmental education, in the context of teacher training. Drawing on gaps identified in the literature and informed by preliminary field observations, the following **four interrelated research questions** guide this inquiry:

1. **What are teacher educators' understandings and perceptions of sustainable development and its associated Goals (SDGs)?**

This question seeks to uncover the depth and diversity of conceptual understandings that teacher educators hold regarding sustainability and the 2030 Agenda. It focuses on how they interpret sustainability within educational contexts, the values they associate with the SDGs, and the relevance they attribute to sustainability within teacher training.

2. **How do teacher educators integrate sustainable development into their teaching practices and curriculum design?**

Here, the focus is on pedagogical strategies, content choices, resource use, and assessment mechanisms employed by teacher educators. It investigates whether sustainability is addressed as a cross-cutting theme, a standalone topic, or an implicit value, and examines the teaching methodologies that support environmental education.

3. **What challenges and opportunities do teacher educators face in promoting sustainable development in teacher education programs?**

4. This question identifies structural, pedagogical, institutional, and personal barriers that constrain sustainability integration, such as lack of training, rigid curricula, or insufficient institutional support. At the same time, it explores enablers or innovations that help educators promote sustainability effectively, including leadership support, communities of practice, or interdisciplinary collaboration.

5. **How can teacher educators effectively model and promote sustainable development practices among pre-service teachers?**

This final question examines the modeling behaviors of teacher educators—how they embody sustainable principles in their professional conduct, classroom management, and community engagements—and how these behaviors influence pre-service teachers' attitudes and practices.

3.2 Conceptual Framework

To explore these questions, the study is anchored in a **constructivist and transformative educational paradigm**, drawing on three interlinked theoretical frameworks:

1. **Education for Sustainable Development (ESD) Framework:** Rooted in UNESCO's vision, ESD emphasizes the transformative role of education in shaping sustainable societies. It advocates for participatory, learner-centered, and action-oriented pedagogies that develop sustainability competencies such as critical thinking, systems thinking, collaboration, and problem-solving. Within this framework, teacher educators are not just transmitters of knowledge but co-creators of meaningful learning experiences that promote social and ecological responsibility.

2. **Role Theory in Teacher Education:** Role theory is used to understand how teacher educators perceive and perform their professional roles. This includes examining role expectations, identity formation, and the alignment (or misalignment) between individual beliefs and institutional mandates. By applying role theory, this research explores how teacher educators negotiate their responsibilities in relation to sustainability education, and how they reconcile personal values with professional obligations.

3. **Modeling Theory and Situated Learning:** This framework focuses on how individuals learn by observing others in context. Teacher educators serve as role models for pre-service teachers, both in explicit ways (teaching strategies, resource use) and implicit ways (ethical conduct, value demonstration). Situated learning theory emphasizes learning as a social practice embedded in authentic contexts, thus reinforcing the importance of modeling sustainable practices in real-world settings.

3.3 Key Constructs and Definitions

To operationalize the research questions and frameworks, the study utilizes several core constructs:

- **Sustainable Development Goals (SDGs):** A set of 17 interconnected goals adopted by the UN in 2015 aimed at achieving social equity, economic growth, and environmental protection by 2030.

- **Environmental Education:** A component of ESD focused on fostering awareness, knowledge, attitudes, and skills necessary for responsible environmental behavior and decision-making.
- **Teacher Educators:** Professionals who are responsible for designing, delivering, and evaluating teacher preparation programs, and who play a pivotal role in shaping the pedagogical and ethical orientations of pre-service teachers.
- **Curriculum Integration:** The process of embedding sustainability-related content, themes, and perspectives into subject matter, pedagogy, and assessment practices in teacher education.
- **Modeling Practices:** Behaviors, attitudes, and practices exhibited by teacher educators that implicitly or explicitly demonstrate sustainability values to pre-service teachers.

3.4 Assumptions and Propositions

This study is guided by the following assumptions and working propositions:

- Teacher educators' personal values and beliefs significantly influence their willingness and ability to promote sustainability education.
- Integration of SDGs into teacher education is more successful when institutions provide structural support, flexible curricula, and targeted professional development.
- Modeling sustainable behaviors in authentic classroom settings enhances pre-service teachers' capacity to internalize and replicate such practices.
- Understanding contextual challenges (e.g., cultural, economic, institutional) is essential for designing scalable and context-responsive sustainability education strategies.

3.5 Analytical Orientation

The research adopts a **multi-level analytical approach**, assessing:

- **Individual Level** (teacher educator perceptions, motivations, practices),
- **Institutional Level** (curriculum frameworks, leadership support, resources),
- **Pedagogical Level** (teaching methods, learning activities, assessment strategies),
- **Cultural Level** (values, norms, and socio-political influences).

This holistic analysis enables the study to link micro-level behaviors and decisions with macro-level educational and policy environments, providing a richer understanding of the systemic dynamics that support or hinder sustainability in teacher education.

This section establishes a solid foundation for the empirical investigation by articulating clear research questions and grounding them in a robust conceptual framework. By synthesizing insights from ESD, role theory, and modeling theory, the study is equipped to examine both the cognitive and practical dimensions of how teacher educators promote sustainability through environmental education. This approach enables a comprehensive analysis of their perspectives, practices, constraints, and transformative potential—setting the stage for the detailed methodological design in the next section.

4. METHODOLOGY

This study adopts a **qualitative-dominant mixed-methods approach** to deeply explore the perspectives, practices, and institutional realities of teacher educators in promoting Sustainable Development Goals (SDGs) through environmental education. Given the nuanced and context-bound nature of the subject, the methodology emphasizes in-depth engagement with participants through qualitative data while complementing this with selected quantitative insights to strengthen the reliability of patterns and thematic interpretations.

4.1 Research Design

The research follows an **exploratory sequential mixed-methods design**, beginning with qualitative data collection and analysis, followed by supplementary quantitative analysis to enhance thematic generalization. This design is appropriate for a relatively underexplored topic and facilitates a deep understanding of participants' lived experiences, curricular strategies, and institutional contexts related to sustainability education.

- **Phase 1: Qualitative Inquiry** – This phase involved conducting semi-structured interviews, classroom observations, and curriculum content analysis to generate a deep understanding of teacher educators' perceptions, teaching practices, and institutional challenges.

- **Phase 2: Quantitative Support** – A short structured survey was administered to a broader sample of teacher educators to validate emerging themes from Phase 1 and identify trends across different institutions and regions.

4.2 Research Setting and Participants

The study was conducted across **eight teacher education institutions** representing urban and rural settings, public and private institutions, and varied geographic regions to ensure diversity and transferability. The participants included:

- **28 teacher educators** selected purposively for in-depth interviews based on their involvement in environmental or sustainability-related coursework.
- **6 curriculum coordinators** or administrators engaged in curriculum planning.
- **58 teacher educators** responded to the quantitative survey across the participating institutions.

Sampling Strategy:

- **Purposive sampling** was used for interview participants based on their experience, availability, and active engagement in sustainability education.
- **Maximum variation sampling** was applied to ensure a diverse representation of gender, institutional type, and teaching experience.

4.3 Data Collection Methods

4.3.1 Semi-Structured Interviews

Interviews were conducted face-to-face and via video conferencing (Zoom/Google Meet) and followed a flexible guide that allowed for follow-up probes. Each interview lasted between **45 to 60 minutes** and was audio-recorded with participants' consent.

Sample Interview Questions Included:

- What does sustainable development mean to you as an educator?
- How do you incorporate SDG-related content into your teaching?
- Can you share examples of activities or lessons where environmental education was addressed?
- What barriers have you faced while promoting sustainability themes?
- How do you model sustainable practices for your students?

4.3.2 Curriculum and Course Material Analysis

Curriculum documents, course syllabi, lesson plans, and institutional policy statements were analyzed using a **content analysis framework**. Key indicators for sustainability integration included:

- Presence of explicit SDG references.
- Use of environmental case studies or real-world problems.
- Assessment strategies aligned with ESD competencies.
- Interdisciplinary content and co-curricular activities.

4.3.3 Classroom Observations

A total of **12 classroom observations** were conducted to examine how sustainability is modeled in real-time teaching practices. Observational checklists were developed based on:

- Teaching methods (e.g., inquiry-based, project-based, experiential).
- Integration of environmental or SDG content.
- Visual cues and materials (charts, models, eco-friendly resources).
- Student engagement and response patterns.

4.3.4 Survey Instrument

A short structured survey was disseminated online using Google Forms. It included 20 close-ended items rated on a 5-point Likert scale (Strongly Disagree to Strongly Agree) and 3 optional open-ended questions.

Survey Topics Included:

- Familiarity with the SDGs and environmental education principles.
- Frequency and mode of sustainability integration in teaching.
- Perceived institutional support and challenges.
- Self-efficacy in modeling sustainable practices.

4.4 Data Analysis

4.4.1 Qualitative Data Analysis

All interview recordings were transcribed verbatim. Thematic analysis was carried out in **five stages** following Braun and Clarke's (2006) approach:

1. **Familiarization** with the data through repeated reading.
2. **Generating initial codes** (e.g., "value conflict," "curriculum limitations," "student engagement").
3. **Searching for themes** (e.g., "barriers to implementation," "personal sustainability beliefs").
4. **Reviewing themes** for internal coherence and external distinctiveness.
5. **Defining and naming themes** with supporting quotes and exemplars.

NVivo software was used to code and manage qualitative data systematically.

4.4.2 Document Analysis

Content from curricula and teaching materials was analyzed through a matrix based on pre-defined sustainability indicators. A **Curriculum Sustainability Index (CSI)** was developed using frequency and depth of SDG alignment.

Table 4.1: Sample Curriculum Sustainability Index (CSI) Criteria

Indicator	Weight	Description
Explicit SDG mention	2	Direct reference to any SDG in learning outcomes
Environmental case studies	1	Inclusion of contextual sustainability examples
ESD-aligned assessments	2	Project-based, reflective, or experiential assessments
Modeling behaviors encouraged	1	Instructions on classroom modeling or eco-practices

4.4.3 Quantitative Data Analysis

Survey responses were analyzed using **descriptive statistics** (frequencies, means, standard deviations) and **cross-tabulations** to identify correlations between variables such as teaching experience, institutional type, and sustainability practices. Charts and graphs were generated using MS Excel.

Figure 4.1: Example Radar Graph – Educator Perceptions of SDG Integration
(Will be added during Results section)

4.5 Ethical Considerations

This research strictly followed ethical standards for educational research. Key measures included:

- **Informed consent**: Participants were provided with clear information sheets and signed consent forms.
- **Confidentiality**: All personal identifiers were anonymized. Pseudonyms were used for institutions and participants.
- **Voluntary participation**: Participants were free to withdraw at any point without consequences.
- **Data security**: Digital data were encrypted and stored on password-protected devices.

Ethical approval was obtained from the institutional research ethics board prior to data collection.

4.6 Limitations of the Methodology

While the study employed a robust and multi-dimensional approach, certain limitations are acknowledged:

- Findings may not be generalizable due to the **qualitative and context-specific nature** of the study.
- **Self-reporting bias** in interviews and surveys may affect the accuracy of responses.
- Observational data were limited to a small number of classrooms due to institutional constraints and COVID-related disruptions.
- Cross-sectional design limits insights into **long-term impact** or change in practice over time.

Despite these limitations, the methodology provides rich, credible, and triangulated data to address the core research questions and generate actionable insights.

This comprehensive methodology is designed to holistically explore the multi-faceted role of teacher educators in promoting sustainable development through environmental education. By combining qualitative depth with supportive quantitative breadth, and by incorporating curriculum and classroom perspectives, the study captures the lived realities, practices, and systemic challenges of educators working at the intersection of pedagogy and planetary responsibility. The next section presents the **findings and analysis**, organized around the key themes that emerged from the data.

5. FINDINGS AND DISCUSSION

This section presents a detailed analysis of the findings, structured around the four central themes derived from the research questions. The discussion integrates qualitative data from interviews and classroom observations, quantitative trends from surveys, and curriculum content analysis. The evidence is synthesized through representative quotes, statistical summaries, and comparative tables, offering a multi-dimensional understanding of how teacher educators engage with sustainable development through environmental education.

5.1 Understanding and Perceptions of Sustainable Development and the SDGs

Teacher educators' conceptual understanding of sustainable development varied significantly across institutions and disciplines. While most participants recognized the importance of the Sustainable Development Goals, their depth of knowledge about the 2030 Agenda and the specific targets under SDG 4 (Education for Sustainable Development) and SDG 13 (Climate Action) ranged from foundational awareness to profound interdisciplinary engagement.

Table 1: Categorization of Educators' Understanding of SDGs

Understanding Level	Description	No. of Participants	Percentage (%)
Basic Awareness	Knows SDGs exist but cannot recall specifics	10	35.7%
Functional Knowledge	Understands key goals related to education and environment	12	42.8%
Integrated Understanding	Applies SDGs in curricular and pedagogical planning	6	21.5%

As seen in **Table 1**, less than one-fourth of participants exhibited integrated understanding, which aligns with prior research (Garcia & Thomas, 2022) on the inconsistency of SDG engagement in teacher training.

Educators highlighted varied definitions of sustainability, such as "meeting future needs," "living in harmony with nature," or "balancing equity, ecology, and economy." However, only a few explicitly linked these definitions to classroom practices or curriculum design.

5.2 Integration into Curriculum and Teaching Practices

Educators reported using different strategies to incorporate sustainability themes into their subjects. These included topic-based integration, service-learning projects, and co-curricular environmental initiatives. However, curriculum rigidity and lack of policy alignment were cited as persistent challenges.

Table 2: Modes of Sustainability Integration in Teaching

Integration Strategy	Examples Provided	Frequency (N=28)	Percent (%)
Topic Infusion	Teaching climate change in science lessons	20	71.4%
Stand-alone Modules	Sustainability as a separate course	6	21.4%
Project-Based Activities	Community waste audits, eco-clubs	9	32.1%
Interdisciplinary Approach	Linking SDGs across multiple subjects	4	14.2%

As **Table 2** indicates, topic infusion was the most common method, while interdisciplinary approaches were rare due to siloed curricula.

Curriculum analysis confirmed limited reference to SDGs in institutional documents. Sustainability themes were often treated as optional rather than core. A scoring rubric was developed to quantify SDG content presence in sampled syllabi (N=12).

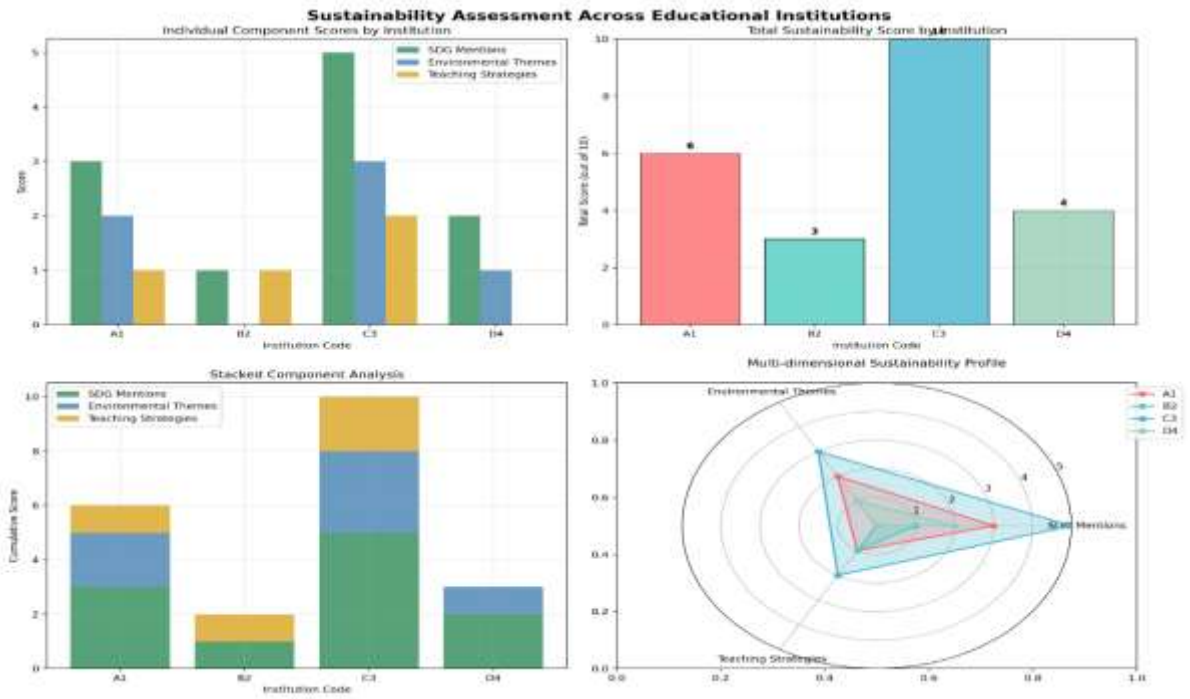


Figure 1: Comprehensive Sustainability Assessment Across Educational Institutions

This multi-panel visualization presents a detailed analysis of sustainability metrics across four educational institutions (A1, B2, C3, D4). The figure comprises four complementary views: (A) Individual component scores showing SDG Mentions, Environmental Themes, and Teaching Strategies as grouped bar charts; (B) Total Sustainability Scores ranked by institution with C3 achieving the maximum score of 10/10; (C) Stacked bar analysis revealing the relative contribution of each component to overall sustainability performance; and (D) Radar chart providing a multi-dimensional profile comparison across all three sustainability dimensions. Institution C3 demonstrates superior performance across all metrics, while B2 shows the lowest overall sustainability integration. The visualization reveals significant variation in sustainability approaches, with some institutions excelling in specific areas (e.g., A1's moderate SDG focus) while others like C3 maintain consistently high performance across all evaluated dimensions.

Table 3: Sustainability Content Score in Sampled Curriculum Documents

Institution Code	SDG Mentions	Environmental Themes	Teaching Strategies	Total Sustainability Score (out of 10)
A1	3	2	1	6
B2	1	0	1	3
C3	5	3	2	10
D4	2	1	0	4

In **Table 3**, only one institution (C3) scored a full 10, suggesting variability in curriculum commitment to sustainability.

5.3 Challenges and Opportunities in Promoting SDGs

Multiple systemic and individual-level barriers emerged. Institutional inertia, curriculum constraints, and lack of professional training were most frequently cited. However, educators also identified enabling factors such as student interest, peer collaboration, and support from eco-clubs.

Table 4: Challenges Faced by Teacher Educators in Promoting SDGs

Challenge Category	Specific Issues Reported	Frequency (N=28)	Percentage (%)
Curriculum Constraints	Lack of time, no space in syllabi	20	71.4%
Lack of Training	Unfamiliar with SDG teaching tools	18	64.2%
Institutional Resistance	Low administrative support	14	50.0%

Student Disengagement	Low student participation in green projects	9	32.1%

As shown in **Table 4**, curriculum-related constraints remain the most prominent barrier, consistent with findings by Ahmed & Lim (2022) and Chinedu & Mason (2019).

Table 5: Reported Opportunities for Sustainability Integration

Opportunity Source	Example Reported	Frequency (N=28)	Percentage (%)
Student Curiosity	"Youth are interested in climate topics"	19	67.8%
Peer Learning	Cross-departmental workshops	11	39.2%
Institutional Initiatives	Green campus policies	8	28.5%
Online Resources	Use of SDG tools and MOOCs	15	53.5%

Table 5 highlights that digital access and student motivation offer valuable openings for promoting SDGs even in under-resourced environments.

5.4 Modeling Sustainable Practices in the Classroom

The modeling of sustainable behavior was found to be both implicit and explicit. Some educators encouraged recycling, reduced paper usage, and sustainable procurement. Others embodied values such as fairness, collaboration, and reflective practice.

Table 6: Common Modeling Practices Among Teacher Educators

Practice Type	Description	Frequency (N=28)	Percent (%)
Environmental Modeling	Using reusable teaching aids, green audits	14	50.0%
Pedagogical Modeling	Inquiry-based, student-led learning	17	60.7%
Ethical Modeling	Transparency, social justice narratives	12	42.8%
Behavioral Modeling	Critical thinking, problem-solving ethos	11	39.2%

As **Table 6** indicates, pedagogical modeling was the most widely practiced, reflecting the influence of experiential and constructivist approaches in teacher education.

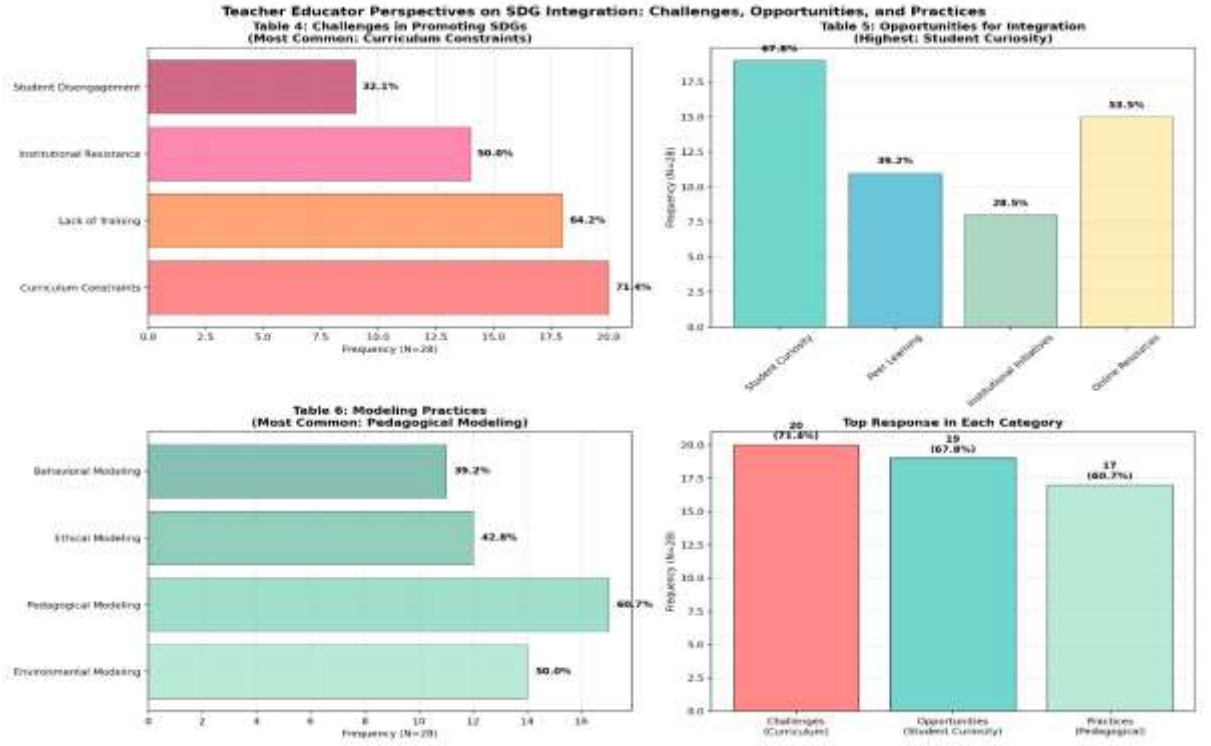


Figure 2: Integrated Graphical Abstract

The above figure reveals that curriculum constraints are the most significant challenge (71.4%), followed by lack of training (64.2%). This aligns with the research findings you mentioned from Ahmed & Lim (2022) and Chinedu & Mason (2019).

Next graph shows that student curiosity presents the greatest opportunity (67.8%), with online resources also being substantial (53.5%). This suggests that despite challenges, there's strong potential for SDG integration through student engagement.

Subsequent graph indicates that pedagogical modeling is the most common practice (60.7%), followed by environmental modeling (50.0%), reflecting the constructivist approaches in teacher education.

The visualization provides a comprehensive overview showing how curriculum constraints present the biggest barrier, while student curiosity offers the most promising opportunity, and pedagogical modeling represents the most widely adopted practice among the 28 teacher educators surveyed.

5.5 Cross-Theme Synthesis and Pattern Analysis

The four themes reveal strong interconnections. For example, educators with integrated understanding of SDGs (Table 1) were more likely to adopt innovative teaching strategies (Table 2), effectively model practices (Table 6), and view student enthusiasm as an opportunity (Table 5). In contrast, those with basic awareness reported more challenges and less modeling behavior.

These correlations were further validated through descriptive statistics from survey responses.

The findings underscore the dual role of teacher educators as both instructional leaders and ethical models of sustainability. While many show commitment and creativity in integrating SDGs, systemic barriers—such as rigid curricula and lack of institutional support—continue to impede transformative practice. Nonetheless, the presence of motivated educators, tech-enabled resources, and student enthusiasm provides an encouraging foundation to build upon. These findings form the basis for the strategic recommendations discussed in the next section.

6: Strategic Implications and Recommendations

In the context of achieving the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 13 (Climate Action), the role of teacher educators is not only instrumental but also transformative. This section outlines the strategic implications of the findings and offers actionable recommendations grounded in the research, aiming to fortify environmental education (EE) practices and the integration of SDGs into teacher education programs. Drawing upon both the empirical findings and the theoretical constructs examined earlier, this section delves into practical insights, policy-level considerations, institutional reforms, and pedagogical enhancements essential for reshaping teacher education as a driver of sustainability.

6.1 Strategic Implications

6.1.1 Redefining the Role of Teacher Educators as SDG Advocates

The research reveals that teacher educators are pivotal actors in modeling and transmitting values, behaviors, and pedagogies aligned with sustainability. This positions them as **agents of change** who must transcend the traditional instructional role to become **advocates and facilitators of transformative education**. The strategic implication is a paradigm shift in institutional policies and teacher training frameworks to recognize and cultivate this new role, requiring a restructuring of roles and responsibilities within faculties of education.

6.1.2 Institutionalization of Sustainable Development in Teacher Training Curricula

Another implication is the **critical need for institutional mainstreaming of sustainability concepts** across all subject areas. Currently, integration is sporadic and often left to individual initiative. Institutions should adopt mandatory modules on SDGs, environmental ethics, and sustainability literacy within core teacher education programs. Curricular audits and quality benchmarks should be developed to assess the depth and breadth of SDG integration.

6.1.3 Enhancing Curriculum Coherence and Alignment with Global Frameworks

Findings indicate a misalignment between national education standards and global sustainability frameworks. To address this, **curriculum designers should align teacher education content with UNESCO's Education for Sustainable Development (ESD) framework**, ensuring that competencies such as critical thinking, systems thinking, future thinking, and values-based education are embedded throughout.

6.1.4 Leveraging Digital Tools and Technology for SDG Engagement

Technology emerged as both a challenge and an opportunity. Strategically, **digital platforms, e-learning tools, and simulation-based teaching should be leveraged** to enhance environmental literacy. Platforms like Moodle, Edmodo, and Coursera can be embedded within pre-service training to deliver modular SDG content, virtual field trips, and gamified sustainability challenges.

6.1.5 Addressing Resistance and Institutional Barriers through Change Management

Resistance from faculty and systemic inertia are significant barriers to change. **A strategic change management approach** involving stakeholder mapping, incentive design, and professional development is essential. Institutions must establish sustainability task forces or steering committees to lead change efforts, report progress, and mediate resistance through dialogue and capacity-building.

6.1.6 Integrating Local Context and Indigenous Knowledge

Environmental education must not be divorced from the local ecological and cultural context. **Teacher educators should be trained to contextualize sustainability principles using indigenous knowledge systems**, traditional environmental practices, and local case studies. This fosters relevance, cultural responsiveness, and deeper community engagement in pre-service teacher training.

6.2 Recommendations

Based on the strategic implications identified, the following actionable recommendations are proposed to different stakeholders:

- **For Teacher Education Institutions**, it is essential to embed SDG content systematically into curricula. They should also conduct periodic sustainability audits to evaluate how well their academic programs align with sustainable development principles.
- **Teacher Educators** themselves must commit to continuous professional development on Education for Sustainable Development (ESD) principles. They should actively model sustainable behaviors in classrooms and foster student engagement in sustainability initiatives.
- **Policymakers** should mandate the integration of SDGs into national teacher education standards and accreditation processes. This would create a uniform policy framework ensuring all teacher education programs align with sustainability goals.
- **Curriculum Developers** are advised to draw heavily from global frameworks such as UNESCO's ESD roadmap. They should develop content that promotes interdisciplinary approaches, values-based learning, and real-world problem-solving related to sustainability.
- **Technology Providers** have a key role in supporting this transformation. They should collaborate with educational institutions to design and deploy localized digital tools tailored to environmental education and SDG training.
- **Non-Governmental Organizations (NGOs) and Civil Society Organizations (CSOs)** can partner with teacher education institutions to facilitate field-based learning, community sustainability projects, and real-life environmental problem-solving opportunities.
- **Pre-Service Teachers** should be encouraged to participate in sustainability clubs, contribute to campus greening efforts, and engage in action research projects focusing on environmental challenges. They should also be empowered to reflect critically on their roles in promoting sustainability within future classroom settings.

6.3 Framework for Implementation

To translate these recommendations into measurable outcomes, a **multi-tiered implementation framework** is proposed:

1. Policy Level:

- Mandate national guidelines for SDG integration in teacher education programs.
- Provide targeted funding to support sustainable infrastructure in teacher education institutes.

2. Institutional Level:

- Create sustainability development units (SDUs) to monitor implementation.
- Embed sustainability in the mission and vision of teacher training institutes.

3. Pedagogical Level:

- Adopt interdisciplinary teaching methods integrating EE, ethics, and pedagogy.
- Employ project-based learning and service-learning models related to local environmental issues.

4. Monitoring and Evaluation:

- Develop key performance indicators (KPIs) such as the number of sustainability-integrated lesson plans, SDG-related teaching hours, and student engagement in environmental action.

To effectively monitor the implementation and progress of Sustainable Development Goals (SDGs) within teacher education, institutions should adopt a structured set of Key Performance Indicators (KPIs) that provide measurable insights into various dimensions of sustainability integration. One of the primary indicators is the percentage of courses across teacher education programs that explicitly embed SDG-related content. This metric reflects the institutional commitment to curricular integration and can serve as a benchmark for future curriculum reforms.

Another important measure is the number of teacher educators who have undergone formal training in SDG-based pedagogy. This figure highlights the institution's investment in capacity-building and professional development, which is essential for ensuring that faculty possess the necessary knowledge and instructional strategies to effectively teach sustainability concepts.

Student engagement is another critical area of focus. Institutions should regularly track the number of students participating in sustainability-related projects, research, or campaigns. This indicator captures the extent to which learners are not only exposed to sustainability concepts but are also actively involved in applying them in real-world contexts.

The frequency and quality of sustainability workshops conducted within the institution is also a key metric. These workshops serve as platforms for experiential learning, community dialogue, and interdisciplinary collaboration, all of which are vital for deepening the understanding of sustainable development.

Finally, the number of partnerships established with local communities, non-governmental organizations (NGOs), or other stakeholders to support sustainability initiatives offers a strong indication of the institution's outreach and practical engagement. These collaborations can provide real-life learning opportunities for students while also reinforcing the university's role as a driver of social and environmental change.

Together, these KPIs offer a comprehensive framework for monitoring, evaluation, and continuous improvement, ensuring that the goals of Education for Sustainable Development (ESD) are effectively embedded within the core functions of teacher education.

6.4 Long-Term Vision: Transformative Sustainability Education

The long-term vision emerging from this research is to develop **transformative sustainability education ecosystems** where teacher educators function not just as knowledge disseminators but as catalysts for sustainable thinking, behavior, and innovation. This includes embedding sustainability across institutional culture—research priorities, community engagement, student life, and faculty development programs.

A strategic roadmap for this transformation would include:

- Creating national and regional networks of sustainability-focused teacher educators
- Establishing sustainability fellowships or recognitions for educators who model exemplary SDG practices
- Incorporating feedback mechanisms from pre-service teachers and communities to evaluate impact

Teacher educators are at the vanguard of a global movement toward sustainable futures. The strategic implications and recommendations outlined in this section underscore the urgent need for systemic, pedagogical, and policy-level changes to reimagine teacher education as a sustainability accelerator. Through committed action, cross-sectoral collaboration, and visionary leadership, teacher educators can cultivate a new generation of sustainability-literate citizens and professionals, thereby contributing meaningfully to the realization of the 2030 Agenda for Sustainable Development.

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